RECEIVED
APR 07 1978
MOP & BML

Marine Skill Report Submitted to the
University of Hawaii Marine Option Program

THE REARING OF TOPMINNOWS IN RICHARDSON'S POND

Duration: August 1, 1977 - October 27, 1977

Project Members: Michael C. Botello
Patrick M. Finnegan
Wallace H. Jennings

Advisor: William Ebersole
Marine Option Program Coordinator
University of Hawaii at Hilo

Report Date: April 5, 1978

Contents

I.	Introduction	1
II.	The History of Richardson's Estate (Pond)	1
III.	Materials and Methods	3
	A. Preparation of the pond	3
	B. Construction of the cages	4
	C. Observations made during the preparation and transportation of the topminnows	5
	D. Growth study observations	7
	E. A previous endeavour	7
IV.	Results	8
V.	Discussion	9
VI.	Evaluation	11
VII.	Bibliography	13
VIII.	List of Figures	14
	Fig. 1 Graph illustrating the growth of juvenile topminnows	
	Fig. 2 Diagram of Richardson's pond	
	Fig. 3 Basic broodpen design	
IX.	List of Appendices	17
	Appendix 1 Raw water quality data	
	Appendix 2 Raw growth data	
X.	Acknowledgments	23

Abstract

Topminnows (Poecilia vittata) were placed in screened cages, secured in Richardson's pond, Keaukaha, Hawaii to evaluate their growth in cool, brackish water. A diet of chicken mash and fish meal was administered to determine if a supplemental feeding program would increase the growth rate. The experiment has shown that the growth rate of the fish was increased substantially by supplemental feeding but that growth was still very slow. The slow growth is believed to be on account of the low water temperature within the pond.

I. Introduction

Topminnows have been introduced as live baitfish for use in the skypjack tuna (katsuwonus pelamis) fishery. Results show that with added research, the fish could replace the formerly used Nehu.

Previous experiments which were done at the Hawaii Institute of Marine Biology indicate that topminnows thrive and reproduce under a variety of environmental conditions. (Herrick & Baldwin, 1975) Thereafter, a project was undertaken to determine whether topminnows could be grown at Richardson's estate in a one-half acre pond.

II. History of Richardson's Estate (Pond)

At present the Richardson Estate is owned by the County of Hawaii and is under the Department of Parks and Recreation. The 4/5 (.8) of an acre pond is just on one side of the Estate. On the King's Landing side (eastside) there is another pond much larger. The County of Hawaii obtained the land from George Richardson.

The Richardsons obtained the land from a Hawaiian family. This family was the Malo family who were kuamo'o.[1] They watched over this land. The land con-

---

[2] Kuamo'o - lineage, as to an ali'i, who would take care of the ali'i belongs, clothes, land, etc. Not to be confused with Kauwa.

sisted of more than what the Richardson estate is today. This area was known as Waiuli (dark waters). The Malo family took care of this land for an ali'i. One of the things that they took care of was the grave site (or cave) of the ali'i. This is not part of the graves that were found on the estate. The graves found on the Richardson estate were that of the Malo family.

In the early 1700's and the late 1800's (from Captain Cook to the missionaries) Ellis writes about the many mono and polyculture ponds that were run by the Hawaiians in the Hilo district.

> "There are plenty of ducks in the ponds and streams, at short distance from the sea, and several large ponds or lakes literally swarm with fish, principally of the mullet kind. The fish in these ponds belong to the kings and chiefs and are tabued from common people."

> "Along the stone walls which partly encircle these ponds, we saw a number of small huts, where the persons reside who have the care of the fish, and are obliged frequently to feed them with a small kind of mussel, which they procure in the sand round the bay."

The coastal pond is in excellent condition, separated from the sea by a mortared stone wall with a single gate for water passage. The pond is also connected tidally to the subsurface salt-water table while having a high, freshwater flow. The water is clear with a cool water temperature, "flushing rates are high but nutrient level of in flowing is high." (Madden and

Paulsen). The small pond section is suitable for a nursery pond. The pond is not currently in use. High primary productivity with high standing crop is possible. Good algae diversity.

III. Materials and Methods

A. Preparation of the Pond

The initial plan was to utilize the entire pond at Richardson's estate for raising the topminnows. Marine Option Program students cleaned the pond and built a gate to seal the entrance of the pond at the ocean.

It was desired to seal the pond from the ocean so that the water level could be kept nearly constant. Therefore, time was spent cementing the more apparent leaks in the wall that bordered the ocean. A number of underwater cementing methods were tried, none of which proved adequate. The rate of flow between the pond and the ocean was slowed, however the range of water level fluctuation did not change.

It was then decided to use the pond as it stood even though the water level would fluctuate with the tide. The fish population (density) would be limited to the amount of water which existed within the pond at the point of the lowest low tide of the year. After observing the lowest low tide of the summer and comparing the magnitude of that low tide to the lowest of the year, it was determined that adequate water remained within the pond to raise topminnows.

The next problem was to eliminate the natural predators found within the pond. This was first attempted by a group of M.O.P. students who tried to drive predators out of the gate and into the ocean with a lay net. It was hoped that by sweeping through the pond with the net all predators would be forced out into the ocean through the opened gate. This method did not work due to the irregularity of the bottom which allowed many safe hiding places for predatory fish.

Alternative methods were also considered. Spear and pole fishing were tried without success. Poisoning and dynamiting were discussed but rejected due to the chance of harming ocean ecosystems outside of the pond.

Our final alternative was to provide protection from predators in a small area of the pond. To do this, we utilized screened enclosures which could be placed within the pond. These would allow the free flow of water but would prohibit the entrance of predators.

B. Construction of the cages

Two cages shown in Fig. 3 were constructed out of wood. These measured 8' x 8' at the base and were each 4' high. The cages were constructed of 2 x 4's and treated with resin to prevent water logging and decay. Both cages had a partition running through the center which separated each cage into two sides of equal dimension. Cage I was covered with 1/4" mesh steel screen, and Cage II covered with standard window screen. Cage I would be used for an adult broodstock and Cage II for growth and feeding experiments.

Locations in the pond were selected for the cages (Fig. 2) where they would at no time be completely submerged and always contain an ample water depth. The cages were then moved into position using small boats and secured on the bottom with sandbags.

C. The preparation and transport of topminnows

One thousand newborn topminnows (P. vittata) were airlifted from Honolulu to Hilo. At H.I.M.B. on Oahu, the topminnows were placed in one-gallon plastic bags which were saturated with oxygen and sealed. Each bag contained approximately five hundred fish in water of optimum quality. The bags were then placed in a styrofoam cooler which was also sealed. The fish remained sealed within the cooler for six hours. After arrival in Hilo, the cooler and bags were opened but the topminnows remained in them for the next 12 hours without aeration. There was no apparent mortality.

The baby topminnows were transferred to a fifty-gallon barrel containing ten gallons of aerated water. Water quality was kept near optimum with a salinity of 17% and a temperature of 23°C. (Herrick and Baldwin, 1975)

The next morning the keikis were fed freeze-dried zooplankton. An initial length measurement of 10 topminnows was then taken.

After remaining in the barrell for four days, the then six-day old fish were transferred into the brood pens in Richardson's pond. The fish were acclimated to the cold brackish water of the pond. (Mean salinity and temperature of 5.0% and 19.5°C.) The bags containing warmer, saltier water were submerged over a fifteen-minute period while mixing in pond water by hand. There was no apparent mortality.

D. Growth study observations

The growth study, designed by a team of M.O.P. students, was used to determine whether or not topminnows (P. vittata specifically) could be raised to mature size in Richardson's pond. And furthermore, it was desired to find out whether a controlled food source other than the benthic algae growing in the pond would bring about a higher growth rate.

Half of the baby topminnows were fed for a three-month period, a ration which varied over the course of the study and the other half were used as comparison controls. Periodic growth measurements were then taken via random sampling from each pen, one containing fish which were fed, and the other containing those which were not.

The initial ration given to the fish consisting of one hundred mls. of chicken feed per five hundred juveniles per day was too much. The ration was then reduced to forty mls. With the arrival of tuna fish meal, the ration was finally changed to thirty mls. of chicken feed and fifteen mls. of fish meal per five hundred fish per day.

E. A previous endeavour

Two months prior to the mentioned growth study, about three hundred adult topminnows and an unknown number of juveniles were airlifted to Hilo. These were placed in a broodpen within the pond. Those fish which could not escape the 1/4" mesh screen remained (50 adults). It is assumed that these continued to reproduce throughout the growth study. During the study, the adults were given a food ration of initially 100 mls. of chicken feed and later both fish meal and egg maker in a ratio of 30:70 mls.

These adult fish were used during the growth study of comparison of adult and juvenile feeding behavior.

IV. Results

Table 1.

Summary of Water Quality Data

1. Salinity	(Percentage)
a) Mean sal.	5.0
b) Variance	0.556
c) Range	3.8 - 6.5
2. Temperature	(^{o}C)
a) Mean	19.5
b) Variance	0.520
c) Range	18.5 - 21.0

Note: Salinity and temperature measured daily except those days when equipment was unavailable or malfunctioning.

Table 2.

Summation of Growth Data

Meas #	Date	$\bar{x}$ fed(cm)	$\bar{x}$ not fed (cm)
1	Aug. 2	0.73	
2	Aug. 10	1.1	1.1
3	Aug. 22	1.2	1.2
4	Sept. 4	1.8	1.5
5	Sept. 16	2.0	1.7
6	Oct. 4	2.5	1.8

Note: Fish born July 31, 1977; first measurement on Aug. 2; feeding begun on Aug. 4 with egg maker; feeding begun on Sept. 4 with tuna meal also.

V. Discussion

P. vittata, the topminnow species under study, has been claimed to be hardy enough to be used as a substitute tuna bait successfully. (Herrick and Baldwin, 1975). Our experience provides exemplification of this hardiness. Newborn keikis survived eighteen hours without aeration in one-gallon bags of salt water. The same fish were then transferred from water with a salinity and temperature of 17.5% and 23^{o}C to water which was measured at 5.0% and 19.5^{o}C in a fifteen-minute period of acclimation. No mortality was observed in either case.

Interesting feeding behavior by topminnows was observed during the growth study. Adult topminnows were observed to feed only on the bottom and to favor a large grain size. Juveniles favored finely graned feed and initially would only take food from the surface. As the young fish grew, they fed further down the water column and would ingest a larger grain size.

The same correlation was observed among the fish which were not fed. They were observed to graze on algae further down the sides of their pen as they grew older. These, however, were never observed to feed on the bottom.

Despite the hardiness of these fish, a study of their growth in Richardson's pond wasn't encouraging. Over a three-month period, those topminnows which were fed grew to 2.5 cm. Figure 1 illustrates the linearity of their growth, always about 1/37 cm per day; less than 1 cm per month. The fish which were not fed grew only 1.75 cm over a three-month period; their growth rate decreasing with time. Feeding the fish resulted in better growth, but even with feeding, something was left to be desired.

Considering water quality as a possible explanation for slow growth, Herrick and Baldwin (1975) state that successful growth and reproduction can be attained with salinity ranging from 3.5 to 17.5% and a temperature ranging from 23.0 to 34.0^{o}C. The salinity range of Richardson's pond was within the recommended limits at 3.8 to 6.8% (refer to Table 1). The temperature however was outside of the limit ranging between 18.5^{o} and 21.0^{o}C (refer to Figure 1). So, it appears that due to cold water, the topminnows could not grow and reproduce successfully. For the evidence obtained to be conclusive, however, additional water quality data should be obtained.

VI. Evaluation

Raising topminnows in Richardson's pond exposed us to problems which are common to many aquacultural endeavours and some which are specific to the culture of topminnows and to Richardson's pond. We met problems involving predation, water quality, food sources, fish containment and obtaining growth related data.

The predation and containment problems were overcome with the use of brood cages which isolated the topminnows from predators and contained them within a small area. As a food source, we provided some fish with a supplemental diet of fish meal and chicken feed. The rest were observed to feed on the benthic algae found growing in the pond. Water quality was less than optimal and was beyond our power to change. The small size and quickness of the topminnows and the depth of the brood cages made the fish difficult to catch for data collection. A brood cage design which eliminated this problem with data collection would greatly increase sampling efficiency as well as render other observations more readily available.

VII. Bibliography

1. Ellis, William. A Narrative of a Tour through Hawaii, or Owghee. Honolulu, Hawaiian Gazette Co., Ltd., 1917. Reprint of the London 1827 edition.

2. George, Milton C. The Development of Hilo, Hawaii TH, A Modern Tropical Sugar Port or a Slice through Time at a Place Called Hilo. Lithographed by the Edwards Letter Shop, Ann Arbor, Michigan, U.S.A., Dec. 1948.

3. Herrick, S. F. and Baldwin, W. J. The Commercial Production of Topminnows. Report prepared by The University of Hawaii Sea Grant Program, January 1975.

4. Madden, William D. and Paulsen, Craige L. The Potential for Mullet and Milkfish Culture in Hawaiian Fish Ponds. Report prepared by the Department of Planning and Economic Development, Feb. 1977.

VIII. List of Figures

Fig. 1 Graph illustrating the growth of juvenile topminnows

Fig. 2 Diagram of Richardson's Pond

Fig. 3 Basic broodpen design

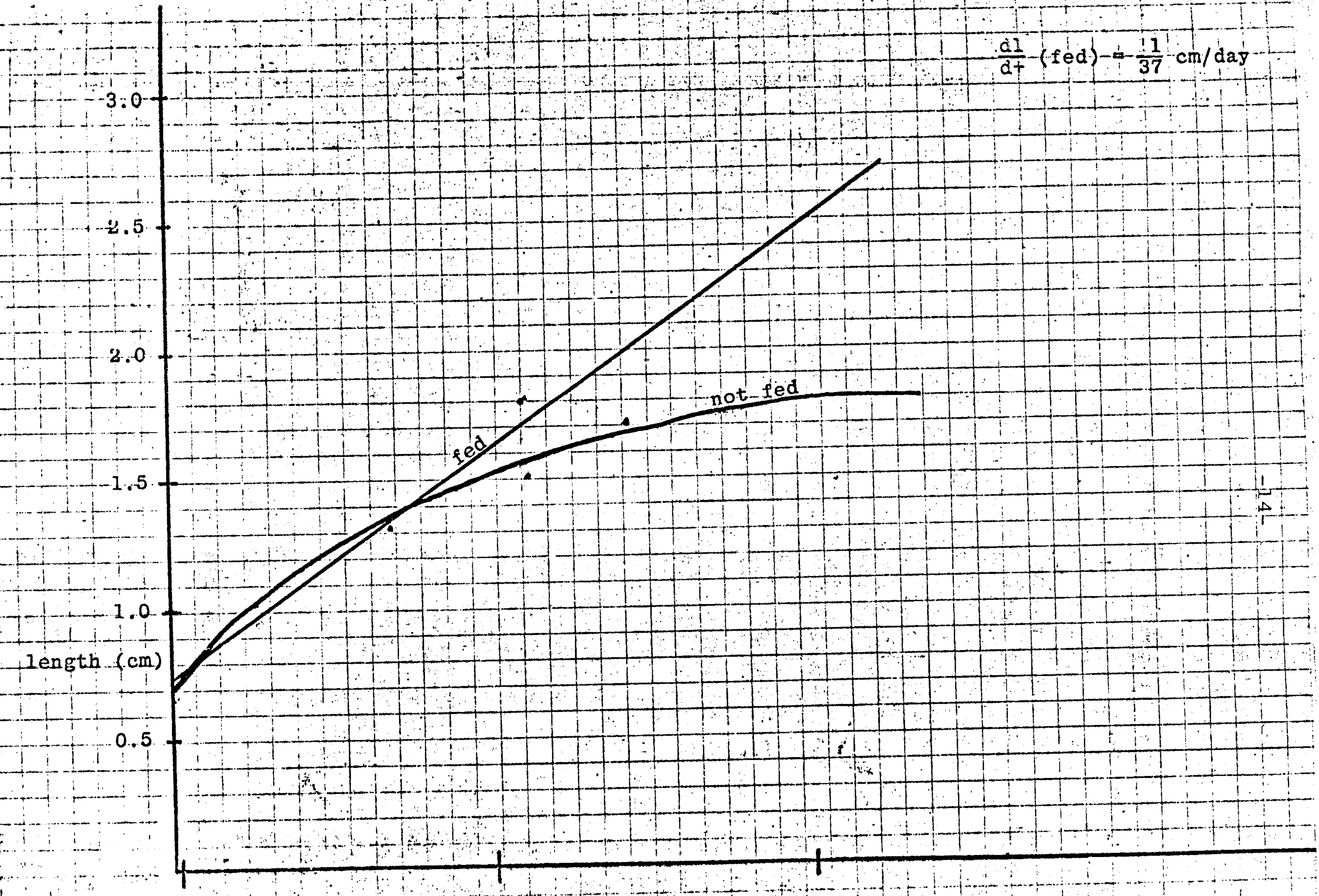
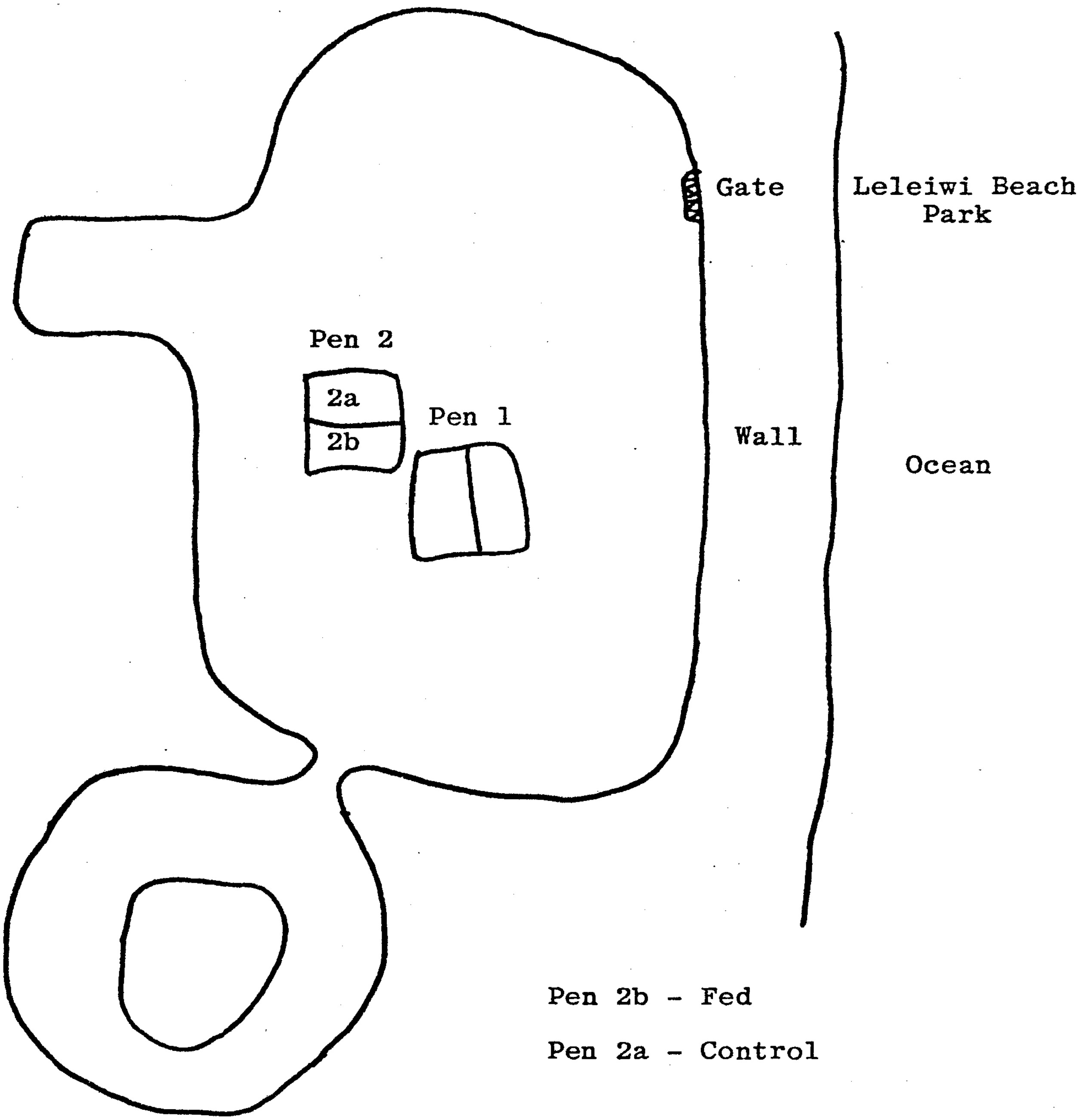


Figure 1. Graph illustrating the growth of juvenile topminnows.

Figure 2.


Gate
Leleiwi Beach Park
Pen 2
2a
2b
Pen 1
Wall
Ocean
Pen 2b - Fed
Pen 2a - Control

Basic Broodcage Design

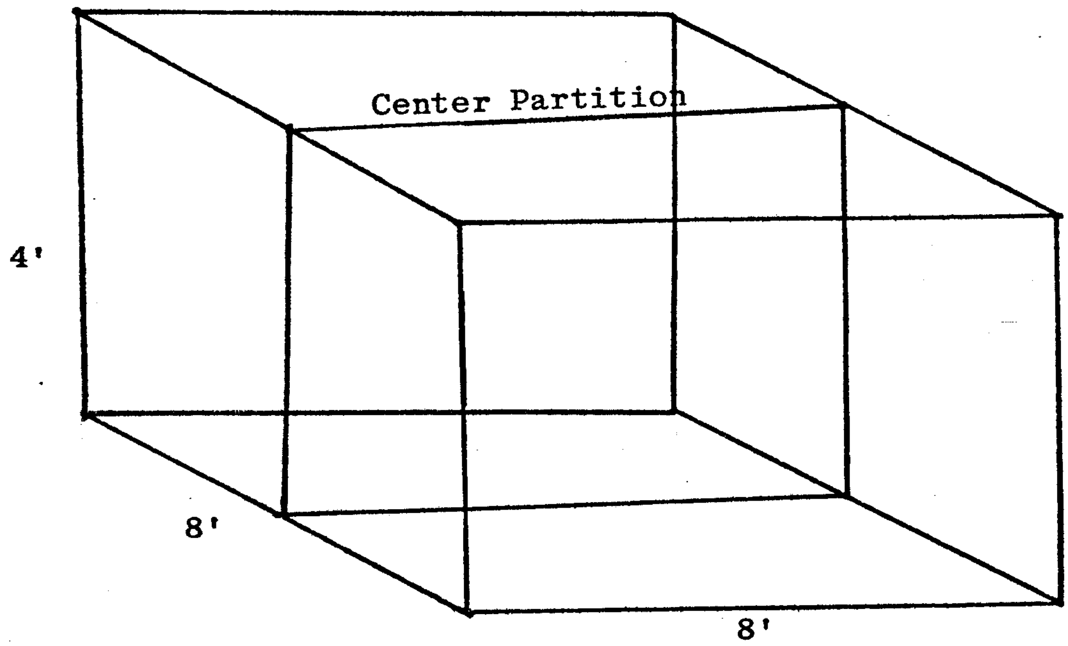


Figure 3.

IX. List of Appendices

Appendix 1 Raw water quality data

Appendix 2 Raw growth data

APPENDIX 1

Water Quality Data

Date	Salinity (%)	Temperature (°C)
Aug. 11	3.8	19.0
" 12	3.8	19.0
" 13	---	----
" 14	---	----
" 15	---	19.5
" 16	---	----
" 17	4.5	2.0
" 18	4.0	19.0
" 19	4.5	20.0
" 20	5.0	20.0
" 21	4.5	19.5
" 22	---	----
" 23	---	----
" 24	4.0	20.0
" 25	3.8	19.5
" 26	5.0	20.0
" 27	4.2	19.5
" 28	---	----
" 29	---	----
" 30	---	----
" 31	5.5	19.5
Sept. 1	5.0	20.0
" 2	6.5	19.5
" 3	6.2	20.0
" 4	5.2	20.5
" 5	5.2	19.5
" 6	5.2	19.5
" 7	---	19.5
" 8	5.2	20.0
" 9	5.0	19.5
" 10	5.2	19.5
" 11	5.1	19.0
" 12	5.1	19.5
" 13	5.2	19.5
" 14	5.2	19.5
" 15	5.2	19.5
" 16	5.0	19.5
" 17	5.0	19.5
" 18	5.0	21.0
" 19	---	----
" 20	---	----

Appendix I (continued)

Date	Salinity (%)	Temperature (°C)
Sept. 21	5.5	19.5
" 22	---	19.5
" 23	---	19.5
" 24	6.0	19.5
" 25	5.2	19.0
" 26	---	----
" 27	5.0	20.0
" 28	5.2	18.5
" 29	3.8	20.0
" 30	4.5	19.5
Oct. 1	5.2	18.5
" 2	5.2	18.75
" 3	5.0	18.75
" 4	---	18.5

APPENDIX 2

Growth Measurements (in cm)

Meas. 1 — **Aug. 2**

Xi	fi
0.60	3
0.70	3
0.75	2
0.80	1
1.10	1

$\bar{x}$ = 0173 cm

variance = 0.252 cm

range = (0.60-1.10) cm

Meas. 2 — **Aug. 10**

Fed

Xi	fi
1.0	4.0
1.1	3
1.2	1
1.3	2

$\bar{x}$ = 1.1 cm

variance = 0.110 cm

range = 1.0 - 1.3 cm

Not fed

Xi	fi
1.0	4
1.1	3
1.2	1
1.3	2

$\bar{x}$ = 1.1 cm

variance = 0.120 cm

range = (1.0-1.3) cm

Appendix 2 (continued)

Meas. 3 Aug. 22

Fed

Xi	fi
1.1	3
1.2	5
1.3	2

$\bar{x}$ = 1.20 cm

range = (1.1-1.3) cm

variance = 0.06

Not fed

Xi	fi
1.1	5
1.2	2
1.3	3

$\bar{x}$ = 1.2 cm

variance = 0.09 cm

range = (1.1-1.3) cm

Meas. 4 Sept. 4

Xi	fi
1.5	2
1.7	1
1.8	3
2.0	2

$\bar{x}$ = 1.8 cm

variance = 0.173 cm

range = (1.5-2.0) cm

Not fed

Xi	fi
1.2	1
1.5	4
1.6	1
1.7	1
1.8	1

Appendix 2 (continued)

Meas. 4 (continued)

$\bar{x}$ = 1.5 cm

variance = 0.16

range = (1.2-1.8)cm

Meas. 5 Sept. 16

Fed

Xi	fi
1.7	1
1.8	2
1.9	1
2.0	4
2.1	1
2.2	1

$\bar{x}$ = 2.0 cm

variance = 0.16 cm

range = (1.7-2.2) cm

Not fed

Xi	fi
1.5	2
1.6	4
1.7	2
1.8	1
2.0	1

$\bar{x}$ = 1.7 cm

variance = 0.16 cm

range = (1.5-2.0) cm

Appendix 2 (continued)

Meas. 6 Oct. 4

Fed

Xi	fi
2.0	2
2.3	1
2.5	3
2.7	2
3.0	2

$\bar{x}$ = 2.5 cm
variance = 0.36 cm
range = (2.0-3.0)cm

Not fed

Xi	fi
1.5	2
1.7	2
1.8	1
1.9	1
2.0	3
2.2	1

$\bar{x}$ = 1.8 cm
variance = (calculate) 0.23 cm
range = (1.5-2.2)cm

X. Acknowledgments

We would like to thank Dr. Samuel Baldwin, Bill Ebersole, Jim MacNeil, Dale Kreps, Dale Sims and all who helped with pond cleaning, fish chasing and cement work for their kokua. Also, we would like to thank La Vanda Warren for typing this paper.